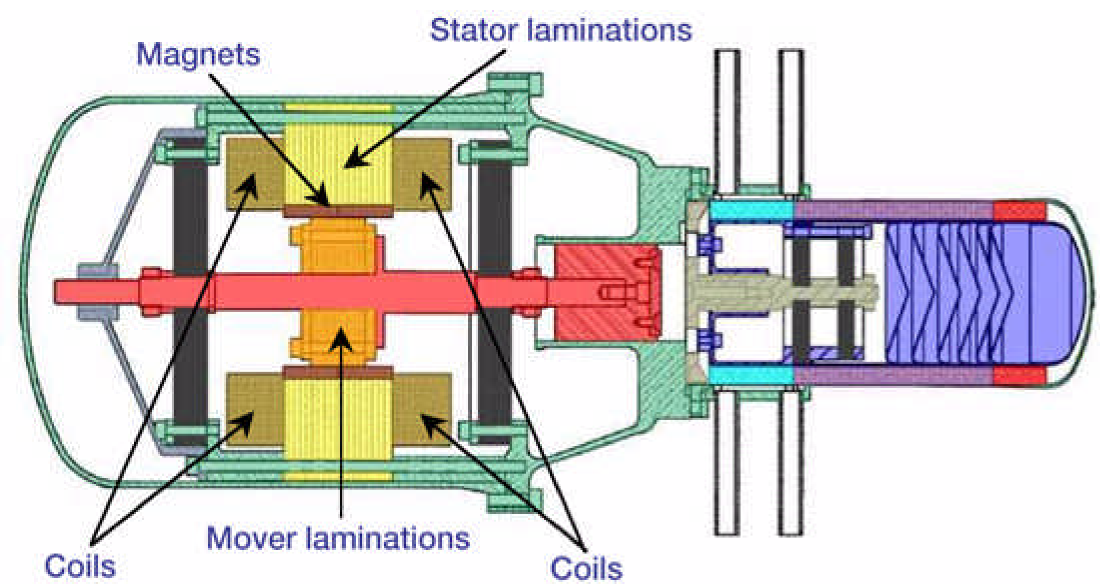
Three-Dimensional Magnetic Analysis Technique Developed for Evaluating Stirling Convertor Linear Alternators

The Department of Energy, the Stirling Technology Company (STC), and the NASA Glenn Research Center are developing Stirling convertors for Stirling radioisotope generators to provide electrical power for future NASA deep space missions. STC is developing the 55-We technology demonstration convertor (TDC) under contract to the Department of Energy. The Department of Energy recently named Lockheed Martin as the system integration contractor for the Stirling radioisotope generator development project. Lockheed Martin will develop the Stirling radioisotope generator engineering unit and has contract options to develop the qualification unit and the first flight unit. Glenn's role includes an in-house project to provide convertor, component, and materials testing and evaluation in support of the overall power system development. As a part of this work, Glenn has established an in-house Stirling research laboratory for testing, analyzing, and evaluating Stirling machines. STC has built four 55-We convertors for NASA, and these are being tested at Glenn. A cross-sectional view of the 55-We TDC is shown in the figure. Of critical importance to the successful development of the Stirling convertor for space power applications is the development of a lightweight and highly efficient linear alternator. In support, Glenn has been developing finite element analysis and finite element method tools for performing various linear alternator thermal and electromagnetic analyses and evaluating design configurations.



Cross section of STC's 55-We technology demonstration convertor (TDC).

A three-dimensional magnetostatic finite element model of STC's 55-We TDC linear alternator was developed to evaluate the demagnetization fields affecting the alternator magnets. Since the actual linear alternator hardware is symmetric to the quarter section about the axis of motion, only a quarter section of the alternator was modeled. The components modeled included the mover laminations, the neodymium-iron-boron magnets, the stator laminations, and the copper coils.

The three-dimensional magnetostatic model was then coupled with a circuit simulator model of the alternator load and convertor controller. The coupled model was then used to generate alternator terminal voltage and current predictions. The predicted voltage and current waveforms agreed well with the experimental data, which tended to validate the accuracy of the coupled model. The model was then used to generate predictions of the demagnetization fields acting on the alternator magnets for the alternator under load.

The preliminary model predictions indicate that the highest potential for demagnetization is along the inside surface of the uncovered magnets. The demagnetization field for the uncovered magnets when the mover is positioned at the end of a stroke is higher than it is when the mover is at the position of maximum induced voltage or maximum alternator current. Assuming normal load conditions, the model predicted that the onset of demagnetization is most likely to occur for magnet temperatures above 101 °C.

Find out more about the research of Glenn's Thermo-Mechanical Systems Branch http://www.grc.nasa.gov/WWW/tmsb/.

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